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METALLURGICAL PROGRESS REPORT

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Number 26

Quarter Ending

MARCH 1965

UNITED STATES DEPARTMENT
OF THE INTERIOR
BUREAU OF MINES

Albany Metallurgy Research Center
Albany, Oregon

A. H. Roberson,
Research Director

Printed in USA. Price $2.00 . Available from the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Virginia

Report No. USBM-RC-1158
UC-25, Metallurgy and Ceramics
TID-4500 (37th Edition)

QUARTERLY

METALLURGICAL PROGRESS REPORT

Number 26

For the period of
January 1 through March 31, 1965

AEC Contract Number AT(11-1)-599
Activity Number 4420

Prepared by
United States Department of the Interior
Bureau of Mines
Albany Metallurgy Research Center
Albany, Oregon

A. H. Roberson
Research Director

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TID-4500 (37th Ed.)
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SUMMARY

HIGH MELTING POINT CARBIDES (HfC)

Work continues on the preparation of hafnium carbide-carbon alloys for tensile and bend rupture tests. Composition ranges from 12.8 percent carbon down to nearly stoichiometric carbide.

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Hafnium carbide castings with total carbon contents ranging from about 8.5 to 11.5 weight percent were tested for tensile properties at temperatures ranging from 20° to 2,180° C. Modulus of elasticity values for 20°, 1,100°, and 1,580° C were calculated.

THORIUM ALLOY SYSTEMS

The preparation of homogeneous alloys by blending spheroidal thoria and thorium powder with suitable binders is being attempted. The effect of organic binders on the carbon content, fabricability, and tensile properties of the alloys was investigated. Although an increase from 0.1 to 0.6 percent carbon was observed, no significant changes in fabricability or tensile properties were noted.

COLD-MOLD INDUCTION MELTING

Efforts toward cold-mold induction melting have centered on scaling up the equipment and renovating a "surplus" power unit. Preliminary tests of the 1-1/2-inch-diameter ingot unit are favorable to success when the larger power unit is installed.

INVESTIGATION OF THE SYSTEM UC-UN-UO

Most of the effort this period has been directed toward the improvement of techniques in studying the UC-UN-UO system. Attempts have been made to reduce the degree of oxidation of fine powders by improvement of the quality of the glove box atmosphere. Studies are being conducted on sintering, in hopes of minimizing both decomposition of specimens and back-reaction of specimens with carbon monoxide. Composition control appears to be the major problem in the study.

TUNGSTEN-RHENIUM TUBING DEVELOPMENT

Four arc-melted billets of W-25 Re alloy have been delivered to Oak Ridge National Laboratory for subsequent extrusion to tube blanks and sheet bars.

In the continuing program to prepare W-25 Re alloys by powder metallurgy techniques, twenty-one alloy sleeves were prepared and eleven were shipped to Nuclear Metals, Inc. for extrusion. Prealloyed W-25 Re powders were obtained from two sources for evaluation.

RHENIUM AND RHENIUM-BASE ALLOYS

Tungsten and rhenium powders were blended and consolidated into ingots having the W-25 Re composition by powder metallurgy techniques and consumable electrode arc melting. The ingots were sampled for metallographic and chemical evaluation and then shipped to Oak Ridge National Laboratory for extrusion into sheet bars.

QUARTERLY

METALLURGICAL PROGRESS REPORT

Number 26

AEC Contract No. AT(11-1)-599
Activity Number 4420

HIGH MELTING POINT CARBIDES (HfC)

R. A. Beall and H. Kato, Project Coordinators

Fused Hafnium Carbide - R. P. Adams

The objective of this program is to spin-cast suitable specimens of high melting point metal-carbon alloys for property evaluation.

More than forty specimens have been cast this quarter with the newly developed external threaded molds. The castings have a reduced center section over 1 inch long and are 5/16-inch in diameter. The end sections of the mold are threaded on the outside with a 1-inch N. C. thread. These sections are left on the casting and are screwed into the grip for hot testing. Three of these specimens were sent to Southern Research Institute.

Several of these specimens have been cast from high carbon compositions (a maximum of 12.8 weight percent C). At the present time, castings are being made from a lower carbon composition, and it is hoped to go down the range until cracking becomes apparent in the near stoichiometric compositions. Electrodes have been made in the hafnium-carbon compositions of 4 weight percent to 14 weight percent carbon.

Rectangular castings 1/4-inch by 1/2-inch by 3 inches long are being cast from the various hafnium-carbon compositions for use in bend rupture tests.

Electrodes have been pressed and sintered containing tantalum-carbon, niobium-carbon, and zirconium-carbon compositions. These will be made into castings as soon as the present series of hafnium-carbon specimens is completed.

Quality Evaluation of Carbide Specimens - M. I. Copeland

The objectives of the high melting point carbide project for the Physical Metallurgy Laboratory are to evaluate the quality of carbide castings produced by the Melting Laboratory and to determine selected properties. The quality of carbide castings are evaluated by visual, chemical, metallographic, radiography, and penetrant inspection. The resistance to external loading is the primary property being investigated for the present.

All but 6 of the 33 castings evaluated for quality were made for obtaining tensile test data. These castings contained hafnium carbide and excess carbon as graphite. The total carbon content ranged from about 8.5 to 11.5 weight percent carbon. The majority of the castings were of an improved design using threaded graphite grips for tensile testing. The grips were part of the mold into which molten material was cast and they were left on the casting. Excellent seating of the tapered portion of the castings in the grips was observed. The casting in the grips tapered to the gage section which measured about 1-inch long and 5/16-inch in diameter. The quality of these castings was much better than those previously made. Although most of the castings contained a slight amount of centerline porosity in one end of the gage section, only 6 castings were deemed unsuitable for tensile testing.

Six bend specimens 3 inches long with rectangular cross section measuring 1/2- by 1/4-inch were evaluated. Four of these castings were cracked and the other two had a slight amount of porosity.

Selected Property Determination

The first worthwhile tensile data obtained to date were obtained by testing seven castings of the new design. These tests were performed over a range of temperatures in the Marquardt tensile machine using self-resistance heating of the specimen in a vacuum. Also, for the first time an extensometer could be used. Fracture stresses of 11,360, 16,730, 19,150, 6,400, and 6,390 psi were found at 20°, 1,100°, 1,580°, 1,900°, and 2,180° C, respectively. No ductility was noted on the ruptured castings or stress-strain curves except those tested at 2,180° C. Moduli of elasticity of 48 x 10^6, 30 x 10^6, and 14.5 x 10^6 psi were calculated from the stress-strain data on tests conducted at 20°, 1,100°, and 1,580° C, respectively.

> p. 6

A furnace, test jig, and loading equipment were constructed for bend rupture testing of carbide castings. The three-point test jig for holding the castings in the furnace was constructed of boron nitride as a pedestal, and tungsten as contact points. An induction coil powered by a 15 kw radio frequency unit heated the susceptor in the furnace. The susceptor and shielding were made from tantalum foil. This equipment will be used as soon as a sufficient number of bend specimens are available.

A furnace and accessory equipment is being designed for tensile testing carbide castings. The furnace will employ a graphite resistance heater. Support and loading equipment also will be required. Work on this unit was pursued because of the difficulty in controlling temperature and measuring strain in the Marquardt unit now being used.

THORIUM ALLOY SYSTEMS

H. Kato, Project Coordinator
S. A. O'Hare

The development of cermet alloys of thorium containing 15 to 50 volume percent thoria is the primary objective of this project. This development will be concerned with methods for producing the alloys, degree of fabrication of the alloys, and selected mechanical and physical properties of the alloys.

Four batches of thoria, for use in the alloys, was obtained during the quarter from Oak Ridge National Laboratory. The particles were extremely spherical and dense. Average density as determined, was 9.6 g/cc, while theoretical density is 9.991 g/cc.

The production of homogeneous alloys is being attempted by blending the thoria and thorium with suitable binders. Five bodies have been made thus far.

The effect of organic binders on the carbon content, fabrication, and tensile properties was investigated. Two compacts were processed, one with and one without the addition of polyethylene glycol. Carbon increased from 0.1 percent to 0.6 percent, but no significant difference was noted in fabricability or tensile strength.

A statistical test for the randomness of the thoria dispersions in the metal matrix was developed. This test will enable the determination of whether the thoria is present at random locations or at sites caused by the close packing of spheres.

A cursory examination of the effect of low submicron size thoria additions to thorium (dispersion strengthening) is also being studied. A thorium ingot with low oxygen content was hydrided, pulverized, and blended with ThO_2. However, the reaction of the hydride with air during handling increased the oxide content over the desired limit. This work will be repeated using inert chambers and vacuum hot pressing.

Ti, 7.5

COLD-MOLD INDUCTION MELTING

R. A. Beall, Project Coordinator
P. G. Clites

The purpose of this project is to develop a furnace for induction melting reactive metals in a water-cooled copper crucible. Efforts during the past quarter have included attempts to scale up the equipment and to incorporate a sponge side-feeding mechanism into the equipment. A 1-1/2-inch-diameter melting unit was completed and tested as was the side-feeding mechanism. No word has been received regarding the invention report submitted to the San Francisco Operations Office of the U. S. Atomic Energy Commission except that work on the patent is in process.

The 1-1/2-inch-diameter melting unit does not differ from previous units described, and during tests conducted, it appeared to perform satisfactorily. However, the power supply for the furnace is not adequate for producing ingots this large. Attempts were made to melt zirconium and titanium ingots with no success. With zirconium, no melting of a 1-1/2-inch ingot placed in the crucible could be accomplished, and with titanium, only the outer edge of the ingot was melted. A larger power supply has been received from surplus and is now in the process of being repaired. This new power supply will approximately double the power available to the work coil and should be adequate for producing 1-1/2-inch ingots.

The sponge side-feeding mechanism was installed on the furnace and tested with the 1-inch melting unit. A 1-inch-diameter titanium ingot approximately 1-1/4-inch long was melted directly from sponge. The ingot had fair sidewalls and was relatively sound internally. Three or four macroscopic pin holes were observed when the ingot was sectioned longitudinally and are believed to be the result of melting at low power levels. Additional tests with the side-feeding mechanism will be conducted when the larger power supply is available. The tests conducted were very encouraging since no difficulty was encountered from gaseous discharges anticipated when the sponge outgassed on melting, and the work coil was sufficiently shielded from spatter from the melting sponge to prevent shorting out of the coils.

Efforts during the next quarter will include completion of repairs to the larger power supply and testing of units for melting larger ingots.

[Efforts toward cold-mold induction melting have centered on scaling up the equipment and renovating a "surplus" power unit. Preliminary tests of the 1½ inch-diameter ingot unit are favorable to success when the larger power unit is installed.]

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INVESTIGATION OF THE SYSTEM UC-UN-UO

p. 14

Hal J. Kelly, Project Coordinator
Jack L. Henry, Danton L. Paulson, and Robert Blickensderfer

The objective of this program is the investigation of the pseudoternary system UC-UN-UO in connection with its usefulness in the production of high-temperature nuclear reactor fuels. Of particular interest are the subliquidus phase relationships within the system and the evaluation of such properties as thermal stability, thermal conductivity, uranium density and hot hardness.

Most of the effort this period has been directed toward seeking optimum sintering techniques for compositions in the UC-UO system and toward the improvement of the glove-box atmosphere.

Materials

In spite of the improvement of the quality of the glove-box atmosphere by the employment of a vacuum antechamber, molecular sieve, and a "getter" furnace, oxidation of fine uranium powder continues to be a problem.

Three batches of uranium powder were prepared to provide material for body preparation and to study the hydriding technique and powder oxidation. Data from these runs are shown in table 1.

It appears that hydriding and dehydriding the material two times results in a finer powder, but the oxygen content is increased substantially. The increase in oxygen content may be due both to the smaller particle size (greater surface area) and to the longer exposure to traces of oxygen in the hydrogen gas during hydriding. No attempt has been made yet to determine the particle size distribution of the minus 200-mesh powder.

Equipment and Facilities

Considerable data have been gathered on the moisture content of the glove box atmosphere by the employment of a C. E. C. moisture monitor. The lower limit appears to be about 10 ppm, but the moisture level rises to near 100 ppm when the neoprene gloves are first inserted into the box. Other investigators have also experienced this diffusion of moisture through neoprene gloves. During the time that powder handling is conducted, the moisture level is usually between 40 and 60 ppm.

TABLE 1 .- Uranium hydriding tests.

Batch	Hydriding and dehydriding time (hrs)	Powder for analysis	Oxygen (ppm)	Usable powder recovery (%)
7	3 Hyd.	unground	1,380 , 1,170	
	2 Dehyd.	-60, + 100 mesh	1,010 , 1,350	
		-100, + 200 mesh	1,300 , 1,360	
		-200 mesh	1,020 , 1,090	
				50
8	20 Hyd.	unground	1,375 , 1,300	
	3 Dehyd.	-200 mesh	2,540 , 2,520	
				55
9	4 Hyd.	unground	4,750 , 6,650	
	2 Dehyd.	-200 mesh	6,120 , >6,000	
	15 Hyd.			
	3 Dehyd			
				89

Without an argon circulation system it is not possible to take full advantage of the molecular sieve for moisture removal. Thus far oxygen content has not been determined, but it is hoped that the "getter" furnace is reasonably effective in maintaining a low level.

Problems are still being experienced with outgassing during high temperature operation of the vacuum sintering furnace. Although the room temperature outgassing rate is less than 0.05 microns per minute, the outgassing rate at 1,700° C is over 1 micron per minute. Mass spectrometric analyses show the residual gas to contain hydrogen and carbon monoxide together with minor amounts of nitrogen, water vapor, and oxygen. The large amount of hydrogen indicates moisture in the system. Replacement of the graphite hairpin heater with a molybdenum heater did not alter the outgassing rate.

Tests are being conducted to determine the effect of the outgassing on specimen composition during high-temperature sintering.

An attachment has been designed and constructed for use in measuring decomposition pressures. This consists of a closed-end seamless molybdenum tube which will be heated by the graphite heater. The upper end of the tube is water-cooled and will be attached to the vacuum system and to a vacuum gauge. Outgassing within such a system should present less of a problem than now experienced with the vacuum furnace.

<u>System Study</u>

An experiment was conducted in an attempt to determine the cause of the apparent loss of free UO_2 from many uranium oxycarbide and oxynitride bodies. It was postulated that the free UO_2 may be reacting with free uranium to produce volatile UO. To check this hypothesis, uranium metal contained in a UO_2 crucible was covered by a pure uranium carbide wafer and heated to 1,700° C for 30 minutes. Should UO volatilize from the UO_2 crucible containing metallic uranium, a weight loss would result and a slight decrease in lattice parameter from UO solution in the UC structure may result.

A small weight loss was noted for the UO_2 crucible and metal and a metallic coating was evident on the exposed surface of the UC wafer. The UC wafer, however, lost considerable weight. Because of the apparent decomposition of the UC wafer, no conclusions could be drawn from the experiment. The experiment will be repeated at a later date under more controlled conditions.

A series of sintering tests has been completed using the nominal composition $U(C_{.70}O_{.30})$ in an attempt to establish near-optimum sintering conditions for the vacuum furnace being used. It is hoped that extraneous carbon monoxide buildup can be controlled by proper throttling of vacuum valves to minimize back-reaction with the specimen or prevent specimen decomposition. Such conditions appear to be mandatory for firing U(CO) bodies and also U(CON) ternary bodies if compositions are to be controlled.

Twelve bodies weighing about 3.5 grams each were prepared from one large batch of U, C, and UO_2 powder. These bodies were fired in duplicate to examine 6 sintering schedules as follows:

1. No prefire - fire 1,700° C 1 hr, headgate closed.
2. No prefire - fire 1,700° C 1 hr, throttled at 20 microns.
3. Vacuum prefire, 1,050° C 1 hr, fire 1,700° C 1 hr, headgate closed.
4. Vacuum prefire, 1,050° C 1 hr, fire 1,700° C 1 hr, throttle at 20 microns.
5. Prefire 1,050° C 1 hr, throttle at 1 micron, fire 1,700° C 1 hr, headgate closed.
6. Prefire 1,050° C 1 hr, throttle at 1 micron, fire 1,700° C 1 hr, throttle at 20 microns.

A correction was made for the oxygen content of the uranium powder to produce a nominal composition which would lie on the UC-UO binary join. The results of this experiment are shown in table 2.

Because of the reaction of so many of the bodies with the molybdenum support, the data are somewhat inconclusive. Unfortunately, it is not possible from these results to determine the best sintering schedule. It would appear that throttling at 20 microns or allowing a pressure buildup to 100 to 200 microns makes little difference. The effect of prefiring temperature may be a more important factor. Another experiment is underway to study prefiring temperatures. These bodies will be placed on a tungsten sheet to eliminate the problem encountered with molybdenum.

Three of the bodies, UCON 102, 106, and 111 appeared to have failed to sinter. This is evident from the higher lattice parameter and free UO_2 content. These bodies have been refired, but the data are not yet available.

TABLE 2. - Sintering schedule study of $UC_{.70}O_{.30}$ bodies.

UCON no.	Schedule	Temp. max. °C	Pressure, microns	Density g/cm^3	Lattice parameter Å	% free UO_2	Reaction with Mo support	Metallographic description
110	I	1,660	190	--	4.9509	0.7	yes	Three phase, 8%U, 1% UO_2, UO_2 concentrated on edge.
111	I	1,690	250	8.5	4.9527	2.0	no	Three phase. <0.1%U, 2-3% UO_2, Large gr.
101	II	1,710	7-20 (45 max)	9.6	4.9510	0.7	yes	Three phase, 5%U, <0.5%UO_2, UO_2 concentrated on edge.
104	II	1,670	12-25	10.3	4.9512	0.6	yes	Three phase, 5%U, 1%UO_2, (3-5%Mo spec. anal.)
105	III	1,065 1,680	(hi vac) 160	9.8	4.9509	0.4	yes	Three phase, <5%U, (1-3%Mo spec. anal)
108	III	1,050 1,670	(hi vac) 210	10.0	4.9521	0.8	yes	Three phase, <5%U, ragged voids. 1-2% UO_2
106	IV	1,050 1,690	(hi vac) 17-20 (100 max)	7.2	4.9555	2.4	no	Two phase. Small ragged grains. 3%UO_2 poorly dispersed. (0% Mo spec. anal).
107	IV	1,050 1,680	(hi vac) 6-29	9.6	4.9510	0.2	yes	Three phase. 3-4%U, UO_2 mostly on edges.
103	V	1,070 1,695	1 190	10.2	4.9514	0.2	yes	Three phase. Similar to 101.
109	V	1,060 1,685	1 125	9.5	4.9506	0.3	no	Three phase. 2%U trace UO_2.
102	VI	1,070 1,680	1 5-28 (100 max)	7.7	4.9560	2.4	no	Two phase. Small ragged grains, 1-2%UO_2.
112	VI	1,063 1,685	1 20-34	8.5	4.9502	0.4	no	Three phase. 1%U, 1% UO_2

Trace Beta uranium found by X-ray in UCON-101, 102, 103, 104, 107, 108 and 110 Trace Mo found in UCON 104, 107 and 110.

In spite of the reaction with the molybdenum support, most of the bodies display a lattice parameter (average 4.9512 Å) near the value to be expected for $UC_{.70}O_{.30}$. UCON 109 and 112 contain very little free U or UO_2 and are nearly single phase. This indicates that the UO solubility may be equal to or greater than 30 mole percent.

W

TUNGSTEN-RHENIUM TUBING DEVELOPMENT

H. Kato and R. A. Beall, Project Coordinators

Melting - E. D. Calvert

[In the [illegible] program to prepare [illegible] W-25 Re [illegible] by powder metallurgy [illegible] were prepared [illegible]] p 19.

The purpose of this program is to develop techniques leading to the production of good quality tubing of W-25 Re alloy from arc-cast ingots.

Work on this program has been limited to preparation of 4 of the 6 arc-cast W-25 Re ingots produced for extrusion. Two ingots were machined and ground to yield an outside surface finish of 64-32 RMS; a 45° nose angle with a flat leading end surface 1-1/4-inch in diameter was machined on each ingot. A centrally located core 7/8-inch in diameter was removed by electric discharge machining and the resultant bore was honed to a finish of 16 RMS.

Two additional ingots were prepared for extrusion to sheet bar. Conditioning comprised machining and grinding to yield a finish on all surfaces of 64-32 RMS.

All four billets were transmitted to Oak Ridge National Laboratory for extrusion to tube blanks and sheet bar. Plans call for extrusion at 3,400° F at a ratio of 9 : 1. No lubricant will be used other than the volatile oxide of W-25 Re. Actual extrusion will be done on the facilities at Wright-Patterson Field by personnel from Oak Ridge.

The project leader on this program traveled to Cincinnati, Ohio to discuss W-Re research with Mr. C. O. Tarr of GE NMPO and to Oak Ridge National Laboratory to discuss plans for the forthcoming extrusion work.

Evaluation - Gene Asai

The primary objective of this project is to prepare by powder metallurgy, tungsten-25 rhenium alloy sleeves which can be subsequently extruded and drawn into engineering quality tubing. A secondary objective is to evaluate prealloyed tungsten-rhenium alloy powders which are being submitted to this laboratory.

Twenty-one additional tungsten-25 rhenium alloy sleeves were pressed during this quarter. Eleven sleeves have been shipped to Nuclear Metals, Inc. for extrusion, and the other 15 sleeves are at various stages of processing. Problems encountered in the second quarter in maintaining

straightness of sleeve during sintering have been minimized by suspending sleeves during sintering. Sintered sleeves now being prepared are of a tolerable straightness. Out-of-straightness ranges from about 0.01 to 0.018-inch over the 8 inches of length. The density, rhenium content, grain size, and second-phase content were determined for the first 17 sintered sleeves. All sleeves were sintered by heating for 15 hours at 2,400° C in flowing dry hydrogen. The densities ranged from 18.824 to 19.34 g/cc with an average of 19.11 g/cc which corresponds to a value of 97.39 percent of theoretical density. The rhenium content ranged from 24.1 to 25.1 percent with an average of 24.8 percent. Metallographic examination showed them to be free of second phase and to have ASTM grain size of about 5.

Evaluation was essentially completed for the prealloyed tungsten-25 rhenium powder purchased from Curtiss-Wright Corporation. The as-received powders were examined by Fisher subsieve, turbidimetric, Brunauer-Emmett-Teller (B. E. T.), X-ray diffraction, microprobe, and chemical and spectrographic analyses. Impurity contents in the as-received powder and in sintered specimen CW-4N are shown in table 3. The sinterability of this material was studied by sintering sections from a sleeve isostatically pressed at 2,110 kg/cm^2 (30,000 psi). Sintering tests were made at 1,500°, 2,000°, and 2,400° C to yield results summarized in table 4. Although the as-received powder had an average rhenium content of 24 percent, the majority of the individual particles ranged in rhenium content from 8 to 11 percent, while some of the smaller particles contained as much as 83 percent rhenium. The 1.17 micron average particle size powder had a specific surface area of 0.7 square meters per gram. The alloy powder had about the same handling characterisitcs as alloy blends made in Fiscal Year 1964 when 1-1/4-micron particle size tungsten was used. It was processed at 2,400° C without difficulty to yield sintered sleeves of a quality comparable to those currently being made by the use of blended mixtures of elemental tungsten and rhenium. A specimen sintered for 4 hours at 2,000° C was virtually free of second-phase and had a density of 91.4 percent of theoretical. If sintered sleeves of such density could be extruded and drawn to yield tubing of a quality equivalent to tubing currently being extruded from the standard higher density sleeves, it may be advantageous to use prealloyed powder because it can be sintered at lower temperatures to yield finer-grained second-phase-free material. The high iron, chromium, and nickel content of the as-received powder which continued to be high in the sintered specimens should be checked for its effect before definite conclusions are drawn.

TABLE 3. - Rhenium and impurity content in Curtiss-Wright prealloyed W-25Re powder and in sintered sleeves

Element	Supplier's analysis, ppm	Bureau analysis, ppm		
			Sintered CW-4N	
		As-received powder	Turnings	Chunk
Re	24.74 pct	23.7 pct	23.8 pct	-
O	2,800	3,900	-	13
H	160	32	-	0.5
N	660	196	-	40
C	240	74	192	<10
S	5	-	-	-
P	70	-	-	-
Al	<100	10	10	8
Ca	50	-	-	-
Co	20	20	40	30
Cr	500	300	200	200
Cu	10	6	20	0.5
Fe	100	400	400	400
K	<100	-	-	-
Mn	30	30	1	1
Mo	10	10	20	50
Na	50	-	-	-
Ni	200	500	300	700
Si	80	20	10	5
Sn	Not detected	5	10	-
Ti	Not detected	10	10	5
V				5

TABLE 4. - Data for Curtiss-Wright prealloyed tungsten-25 rhenium specimens sintered at various temperatures

Specimen	Sintering conditions	Sample number	Density		Rhenium content, wt pct	Grain size, ASTM No.	Second phase		
			g/cc	1/ Percent of theoretical			Metallography	Microprobe	X-ray diffraction
CW-15	5 hrs - 1,500° C, H_2	B 587	17.65	89.9	24.3	8	10 to 15%	None	Some
CW-20	4 hrs - 2,000° C, H_2	596	17.883	91.4	24.1	7	2/	None	Trace
CW-N	4 hrs - 2,400° C, H_2	590	18.726	95.4	24.3	5	2/	None	3/
CW-4N	15 hrs - 2,400° C, H_2	536	19.256	98.1	23.8	4	None	3/	3/
CW-P	4 hrs - 2,400° C, Vac.	588	19.042	97.0	24.1	5	One glob	None	3/
CW-4P	16 hrs - 2,400° C, Vac.	589	19.168	97.7	23.9	4	2/	None	3/

1/ Based upon theoretical density of 19.625 g/cc.
2/ Not definite.
3/ Not analyzed.

The first one-pound lot of prealloyed tungsten-25 rhenium powder prepared by Union Carbide at Oak Ridge was recently received for evaluation. Evaluation of this material shall be made along the same lines as that described for the Curtiss-Wright material just discussed.

Tungsten and rhenium powders were blended and [illegible] into ingots having the W-25 Re composition by using powder metallurgy and consumable electrode techniques [illegible] end

RHENIUM AND RHENIUM-BASE ALLOYS

H. Kato, Project Coordinator
R. R. Lowery

The objective of this program is to obtain engineering properties on the tungsten-25 rhenium alloy. Alloy produced by both arc-melting (A. M.) and powder metallurgy (P. M.) processes is being investigated.

Powders for the powder metallurgy alloy were tumble blended and screened to produce a uniform composition. Approximately 12 kilograms of alloy were prepared and pressed isostatically at 30,000 psi to form a compact for sintering. After a 2,450° C hydrogen atmosphere sinter for 15 hours, a compact was obtained that finished to a 7.60 cm diameter by 11.50 cm long extrusion billet.

Powders for the arc-melted alloy were also tumble blended and screened, but for a fewer number of tumble-screen cycles. About 14.3 kilograms of alloy were pressed into compacts suitable for consumable electrodes. The compacts were pressed isostatically at 30,000 psi and given first an 8-hour, 1,500° C hydrogen sinter and then a 2-hour, 2,100° C vacuum sinter. The use of these electrodes allowed the arc melting of a rough ingot 8.4 cm in diameter by 14.6 cm in height. This ingot finished to an extrusion billet 7.59 cm in diameter by 12 cm long.

Both P. M. and A. M. extrusion billets have been shipped to Oak Ridge National Laboratory where they will be extruded to sheet bar of 1.27 cm by 5.09 cm cross section. The extrusion ratio will be approximately 7 to 1. When the extrusion is complete, fabrication of the 0.020 and 0.060-inch thick sheet will begin at Albany Metallurgy Research Center.

Metallographic and chemical evaluation of material from both billets are underway.

The project leader of the program traveled to Oak Ridge National Laboratory during the week of February 8 to discuss the extrusion of the alloy billets with Oak Ridge personnel.